TECHNOLOGY NEEDS/OPPORTUNITIES STATEMENT

UNDERSTAND AND QUANTIFY THE RELATIONSHIP BETWEEN CONTAMINANT SOURCES, VADOSE ZONE PLUME PROPERTIES AND GROUNDWATER PLUME PROPERTIES AT HYDROLOGIC BOUNDARIES WITH A FOCUS ON THE GROUNDWATER-VADOSE ZONE INTERFACE

Identification No.: RL-SS32
Date: September 2001

Program: Environmental Restoration
OPS Office/Site: Richland Operations Office/Hanford Site
Operable Unit(s): Broad need potentially applicable to multiple operable units.
PBS No.: RL-SS04 (RL-VZ01)
Waste Stream: Groundwater (Disposition Map Designation: ER-10 [technical risk score 5] and ER-18 [technical risk score 5])
TSD Title: N/A
Waste Management Unit (if applicable): N/A
Facility: N/A

***Priority Rating*:**

This entry addresses the "Accelerated Cleanup: Paths to Closure (ACPC)" priority:

X 1. Critical to the success of the ACPC
____ 2. Provides substantial benefit to ACPC projects (e.g., moderate to high lifecycle cost savings or risk reduction, increased likelihood of compliance, increased assurance to avoid schedule delays)
____ 3. Provides opportunities for significant, but lower cost savings or risk reduction, and may reduce uncertainty in ACPC project success.

***Need Title*:** Understand and Quantify the Relationship Between Contaminant Sources, Vadose Zone Plume Properties and Groundwater Plume Properties at Hydrologic Boundaries with a Focus on the Groundwater-Vadose Zone Interface

Need/Opportunity Category: Technology Need

***Need Description*:** This need addresses specific technical gaps identified in the scope of the Groundwater/Vadose Zone Integration Project (Integration Project) at the Hanford Site and is written as an "integrated" need. The Integration Project is focused on providing the scientific and technical basis to ensure that Hanford Site decisions, including decisions related to long-term stewardship, are defensible and possess an integrated perspective for the protection of water resources, the Columbia River, river-dependent life, and users of the Columbia River resources. As such, this "integrated" need has both applied S&T components that are interrelated in addressing the specified technical gap. Individual efforts applied to resolve the technical gaps described in this need may address all or part of the components identified for this need. Where

a specific technology need can be defined separately from an "integrated" need, a specific technology need statement has been written and is included elsewhere in the Hanford Site STCG Subsurface Contamination Needs (e.g., RL-SS25: Improved, Cost-Effective Methods for Subsurface Access to Support Characterization and Remediation).

This specific need addresses the near-source vertical distribution of contaminants in groundwater. The primary technical gap is an inadequate understanding of the processes that control the transport of contaminants across the vadose zone/groundwater interface and the resulting vertical distribution within the aquifer. Variables involved include: contaminant properties, waste characteristics such as density, chemistry, volume of the waste, influences of artificial water recharge, and the nature of the contaminant release from the vadose zone to the groundwater. This information is important to resolve current inventory estimates associated with groundwater plumes and to estimate the flux of contaminants from the vadose zone to groundwater. Information about vertical distribution of the groundwater plume near the source is also important to help infer how contaminants move through the vadose zone. For example, deeply distributed carbon tetrachloride in the aquifer beneath Plutonium Finishing Plant disposal sites implies drainage of a DNAPL through the vadose zone that "settles" in the aquifer. Contaminant concentrations that are highest in the capillary fringe, or at the very top of the aquifer, would imply unsaturated flow through the vadose zone and a low pore fluid density. Specific needs to address the vadose zone/groundwater interface technical gap include the following.

- Innovative approaches to determine the rate and nature of contaminant delivery from the vadose zone to the groundwater in 3D are needed. These approaches include the reevaluation of historical data to infer vertical distribution of contaminants in groundwater as well as demonstrating effective depth-discrete sampling tools (related to Technology Needs RL-SS03 and RL-SS06).

- Evaluation of temporal issues and relating these issues to seasonal or source term issues is needed to support site-wide assessment. Infiltration rates from the vadose zone to the groundwater control the quantity and timing of contaminant flux.

- Developing an understanding of the relationship between vadose zone capillary fringe and 3D plume geometry in the groundwater near the contaminant sources and controlling processes for contaminant migration through the vadose zone is needed to provide diagnostic information. Recent comments by a peer-review panel for the proposed Hanford site-wide groundwater model pointed out the need for addressing sources of uncertainty, including those introduced by alternate conceptual models. The interface between the vadose and groundwater is a key relationship that needs to be better understood to support analyses that will be performed.

- Techniques that provide representative physical and chemical data during borehole/well installation to delineate contaminant plume distribution and chemistry in the capillary fringe and in the aquifer near the water table are

needed. Techniques are also needed to assess the representativeness and quality of sample/data collection methods for the capillary fringe and groundwater.

Schedule Requirements:

Earliest Date Required: 8/1/99

Latest Date Required: 9/30/05

The Integration Project S&T roadmap (DOE/RL-98-48, 2000) indicates the information that is required over the next 6 years to meet the objectives of the Integration Project. Information associated with the groundwater-vadose zone interface is needed in the FY 2000 to FY 2004 timeframe to meet these objectives.

***Problem Description*:** This need falls under the Groundwater Technical Element within the S&T Endeavor. The Groundwater Technical Element is intended to address and resolve scientific issues related to understanding the role of groundwater in the overall migration of contaminants from the Hanford Site. The objective of the Groundwater Technical Element is to enhance protection of the Columbia River and its environs by 1) determining the existing distributions of contaminants with particular emphasis on 3D distribution especially at the interfaces with the vadose zone and the river and 2) enhancing the understanding of geological, chemical, geochemical, and hydrologic controls for future movement of contaminants. Detection of contaminants in groundwater monitoring wells underlying tanks, cribs, landfills, and other sources has often been the first indication of releases and migration. Understanding the flux and dynamics of vadose-capillary fringe-groundwater contaminant transfer and plume migration in three dimensions is critical to reconstructing vadose zone transport. On a larger scale, transport processes in groundwater control migration to extraction wells or surface water bodies (e.g., the Columbia River), define future risk scenarios, and affect the potential for optimized cleanup. An implicit goal of this research is to provide sufficient knowledge and data and identify existing and new S&T for input to DOE's decision-making process for Hanford cleanup.

This technical element provides the information, analytic capabilities, and understanding required for improving the technical basis for assessments of Hanford Site impacts to groundwater resources and the Columbia River. Groundwater represents an important portion of the potential exposure path and is the link between the source/vadose system and receptors at a well or the river. The technical scope of the groundwater element complements that of the vadose zone element by extending the characterization work into the saturated sediments under the Hanford Site. The saturated zone includes the capillary fringe, the unconfined aquifer, aquitards, and uppermost confined aquifers. The technical scope of the groundwater element also compliments that of the river element by providing input to contaminant flux to the river and other interactions between the groundwater and Columbia River. Major topics include (1) the distribution of contamination within the saturated sediments; (2) the hydrology, geology, geochemistry, and microbiology of the saturated zone; (3) groundwater flow and transport of contamination; and (4) numerical models that depict the movement of water and contaminants.

Benefit to the Project Baseline of Filling Need: Information gained by filling this need will provide appropriate delineation of contaminant distribution and relation of plumes to sources. Thus, there will be less uncertainty in the technical basis used for decisions. The activity that this need supports will be used to support development of the System Assessment Capability (SAC) as part of the GW/VZ Integration Project. Successful completion of these activities is required to meet the objectives of the Integration Project and the related elements of the Paths to Closure.

***Functional Performance Requirements*:** The techniques applied or information that is obtained must delineate contamination and describe processes at the groundwater-vadose zone interface such that the information can be applied toward the conceptual models, fate and transport numerical models, and system assessment capabilities that are being developed as part of the Integration Project. The information must provide a better understanding of current conditions, and the ability to assess potential future conditions for near- and long-term scenarios.

Work Breakdown Structure (WBS) No.*:** 1.4.03.4.4 ***TIP No.:

Relevant PBS Milestone: PBS-MC-042

***Justification For Need*:**

Technical: There is an insufficient understanding of the relationship between vadose zone contamination properties (e.g., the plume distribution, contaminant source properties, waste properties such as density, chemistry, and volume of the waste, and influences of artificial water recharge) and the nature of the contaminant release from the vadose zone to the groundwater. This information is important to resolve current inventory estimates associated with groundwater plumes and to estimate the flux of contaminants from the vadose zone to the groundwater. Information about the groundwater plume below the discharge area is also important to help infer transport of contaminants through the vadose zone.

Regulatory: Information obtained by addressing this need will provide an improved technical basis for making site regulatory decisions and therefore reduce the uncertainty associated with the basis for these decisions.

Environmental Safety & Health: This need addresses broad sitewide technical issues and, as such, crosscuts multiple applications that each may have specific environmental safety and health issues.

Potential Life-Cycle Cost Savings of Need (in $000s) and Cost Savings Explanation:
The estimated life-cycle cost savings associated with filling this need is $200M. This estimate is based on an assumed savings of 5% of the total Hanford remediation life-cycle cost of >$5B. Estimated savings are due to information and data gained by filling this need that supports decisions for cost effective remediation and long-term stewardship.

Cultural/Stakeholder Concerns: This technology need supports the resolution of cultural and stakeholder concerns as expressed by the CRCIA Team in “Columbia River Comprehensive Impact

Assessment, Part II: Requirements for a Columbia River Comprehensive Impact Assessment" (DOE 1998).

Other: None.

Current Baseline Technology: N/A

End-User: Richland Environmental Restoration Project

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DOE End-User/Representative Point-of-Contact: John G. Morse, DOE-RL, (509) 376-0057

Reference:

United States Department of Energy. 1998. Columbia River Comprehensive Impact Assessment, Part II; Requirements for a Columbia River Comprehensive Impact Assessment. DOE/RL-96-16. United States Department of Energy, Richland, Washington.

United States Department of Energy. 2000. Groundwater/Vadose Zone Integration Project Science and Technology Summary Description. DOE/RL-98-48, Vol. III, Rev. 1, U.S. Department of Energy, Richland, Washington.